Guidelines for the Management of Pediatric Diabetic Ketoacidosis

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Please note that guidelines do not substitute for clinical judgment. They are for guidance only.

Pediatric Diabetic Ketoacidosis Guidelines

Departments of Pediatric Critical Care and Pediatric Endocrinology. MMC 2026.

For new onset diabetes in a pediatric patient **NOT** in DKA (see criteria on next page)

- These guidelines may not be appropriate
- Consult endocrine and pediatric admit resident
- Utilize EPIC's Order set labelled **Pedi Diabetes New Onset** and/or discuss with pediatric endocrine.

For any pediatric patient in DKA, whether new onset or not

- Initiate the following guidelines
- Consult PICU (does **NOT** need emergent endocrine consult overnight; team to notify endocrine in early workday hours)
- Utilize EPIC order set labeled **Pedi Diabetes DKA**
  - MMC-POR or MMC-BIDSAN use the **DKA 2-Bag Fluid System Rate Calculator** link in the order set and/or see below.
  - All other hospitals - for fluids
    - If your pharmacy is available and you can utilize the EPIC order set, open **DKA Pediatric Transport Panel** and use the **PICU Transport 2-Bag Fluid System Rate Calculator** link in the order set.
    - If your pharmacy is unavailable or access to the order set is unavailable, please see the image below for saline-based substitutes.

Pediatric DKA Guidelines

- The goal is correction of metabolic acidosis, not euglycemia.

Criteria for diagnosis of DKA.

All 3 must be satisfied

- Hyperglycemic (glucose > 200 mg/dL)
- **AND** Metabolic Acidosis (pH < 7.3, bicarb < 18 mEq/L)
  - Mild pH 7.2-7.3, bicarb 10-18
  - Moderate pH 7.1-7.2, bicarb 5-10
  - Severe pH <7.1, bicarb <5
- **AND** Ketosis – moderate to large in blood and/or urine

Airway / Breathing

- The vast majority of children with DKA will be tachypneic with increased work of breathing, but with a very low CO2 and no oxygen requirements.
- Consider intubation only for **respiratory failure** or for children who are comatose (lost airway protection).
- Be very cautious; it is **impossible** to match the minute ventilation of Kussmaul respirations, which is compensating for metabolic acidosis.

Circulation

- While cautious IV rehydration is recommended, you must first aggressively treat shock.
  - If hypotensive or poorly perfused, give 20 mL/kg isotonic fluid bolus (Lactate Ringer's, Normosol/Norm-R, Normal saline). Repeat as needed until no longer in shock.
- Give a 10-20 mL/kg NS bolus to all other DKA patients (up to 1000 mL max).
- **Make NPO** and proceed to slow IV rehydration using the 2-bag method at a 1.5x maintenance rate, as detailed in the DKA order set or attached.

Disability

- It is common to have some altered mental status in moderate and severe DKA. The cause is likely multifactorial (osmotic, ischemic, and cytotoxic).
- While cerebral edema is a very real possibility (up to 1%), head CT for confirmation is no longer recommended.
- Treat all suspected **clinically relevant** cerebral edema by decreasing your IV fluid rate and consider 0.5-1 g/kg of mannitol.

Initial Laboratory Studies

- CBC
- BMP + Magnesium + Phosphorus
- Urinalysis
- Venous Blood Gas
- If first presentation consider:
  - Thyroid auto Abs (Thyroglobulin Ab screen & Thyroperoxidase Ab)
  - Tissue Transglutaminase (TTG)
  - IgA
  - TSH and T4 are **NOT** indicated due to critical illness

Monitoring Laboratory Studies

- Q1H glucose while on a continuous insulin infusion
- Q2H DKA panel (which includes electrolytes, glucose, pH)
- If abnormalities found on initial labs, treat and monitor until normalized
- Q-void urine ketones (after continuous infusion has finished)

Insulin Treatment

- If the child is in DKA, make NPO and begin a continuous insulin infusion at 0.1 units/kg/hour as soon as initial fluid bolus is complete.
- The **only** indication for a bolus of insulin (0.1 units/kg of regular insulin) is an abnormal delay in obtaining the insulin drip from the pharmacy.
- If the patient has an existing roadmap, please give their long-acting insulin glargine (Lantus/Semglee) daily dose. If no roadmap exists, give 0.3units/kg insulin glargine.
- Adjust your fluid management based on the attached guide. Hypoglycemia is initally treated by increasing the dextrose-containing fluid rate or potentially increasing to 12.5% dextrose, not adjusting the insulin.
- Only decrease the insulin infusion for hypoglycemia that doesn't respond to maximal D10% solution infusion rate. Attempt to not lower below 0.05 units/kg/hour unless insulin glargine has been given or life threatening hypoglycemia / hypokalemia develop.

Cerebral Edema

- **Clinically significant** cerebral edema occurs in up to 1% of pediatric DKA and accounts for 20% of the mortality.
- The actual incidence of brain swelling may be as high as 50% and the causative mechanism is not fully understood.
- It can take up to 24 hours before it develops so close monitoring and high suspicion are required; Q2H neuro checks.
- Major risk factors are elevated BUN, decreased $PaCO_2$, bicarbonate therapy, and sodium not rising as expected.
- Mannitol (0.5-1 g/kg)is the first line for clinically significant cerebral edema with 3% saline (5 mL/kg) second (unlike TBI).

End Point

- **DKA is over when the acidosis is finished, not when you achieve euglycemia**.
- If the anion gap is closed, **AND** the patient is able to take PO food, **AND** the bicarbonate is > 15 (or if bicarb remains <15 and the cause is solely hyper-chloremia), consider starting subcutaneous insulin glargine and 30 min later switching off the infusion with guidance from pediatric endocrine. If glargine has previously been given between 30 min and 24 hours prior, can stop infusion and start roadmap with endocrine guidance.

Sodium	•Sodium usually increases with therapy as the hyperglycemia corrects. You can estimate the 'corrected' sodium using the equation in this guideline. •The recommended IV fluid components in the two bag system helps to mitigate large swings in sodium levels. •Failure of the sodium to rise as expected can be a sign of cerebral edema
Potassium	•Total body potassium is usually quite low despite initial labs. •Initial hyperkalemia is usually caused by profound acidosis shifting K+ into extracellular space. •Hypokalemia can develop as insulin and acidosis correction drives potassium back into intracellular spaces. •Critically low potassium (<2mEq/L) may require a temporary decrease in the iinsulin rate (0.05u/kg/hr) it is preferable to replete the potassium rather than decrease insulin.
Chloride	•Hyperchloremia is a common iatrogenic finding due to excessive saline administration. •Will cause a secondary metabolic acidosis. •Independent risk factor for acute kidney injury. •Prevention is the goal, avoid excessive saline.
Bicarbonate	•Bicarbonate boluses should **only** be given in cases of DKA cardiac arrest. •They are contrainidicated in pediatric DKA and are an independent risk factor for the development of cerebral edema. •Reversal of acidosis, together with acetate and glutamate in the IV fluids, will slowly reconstitute serum bicarbonate.
BUN / Creatinine	•Likely to be high on admission due to dehydration and protein metabolism •Elevated levels are an independent risk factor for cerebral edema.
Glucose	•Euglycemia is not the priority •If hypoglycemic, follow protocol. If persistent, you may increase dextrose containing IV fluids and/or lower insulin infusion to 0.05 units/kg/hr
Phosphate	•Total body phosphate is usually low despite initial labs •Initial hyperphosphatemia from acidosis and dehydration may be replaced with hypophosphatemia; this will need to be repleted with additional IV phosphorus, which is a slow infusion (4-6 hours). •Hypophosphatemia can cause weakness, CNS depression, and cardiac and respiratory failure.
Calcium	•Can decrease with phosphate repletion. •Ideally should check iCal as serum calcium levels will be unreliable with fluid shifts. •iCal will also be lower in acidotic states. •Hypocalcemia can cause cramping, fatigue, irritability.
Magnesium	•Not a huge concern but can potentially be low after prolonged DKA •Consider repletion if lower than 2 mEq/L
Anion Gap	•**The best indicator of success in your therapy**. •When anion gap is closed (12 +/-3) you can consider switching to subcutaneous insulin, turning off the insulin infusion and starting PO feeds; this should be done in consultation with endocrine.

Impact of DKA

- DKA is the most frequent metabolic disorder encountered in the PICU.
- The mortality rate of DKA is approximately 0.5-1%.
- Complications of DKA and/or its therapy include acidosis, cardiovascular collapse, cerebral edema, stroke, pulmonary edema, hypokalemia, hypoglycemia, hypocalcemia, and hypophosphatemia.
- Cerebral edema is a major factor in the morbidity and mortality of DKA accounting for almost 25% of the fatalities.

Pathophysiology

- Relative insulin deficiency leads to an inability of glucose to enter cells and a loss of inhibition of the breakdown of fat, protein, and glycogen.
- This results in hyperglycemia and an increase in β-hydroxybutyric acid and acetoacetic acid (ketones) and hyperlipidemia.
- Hyperglycemia above the renal threshold (approximately 200mg/dL) leads to glycosuria and osmotic diuresis with subsequent loss of water.
- In addition, vomiting adds to the loss of volume
- Subsequent dehydration leads to decreased excretion of ketoacids which results in further increases in these acids and worsening acidosis.

History

- Polyuria, polydipsia, weight loss, abdominal pain, nausea, vomiting, recent viral or bacterial infection

Physical Exam

- Dehydration, Kussmaul respirations, fruity odor.
- Delayed capillary refill, orthostatic hypotension, altered mental status (follow closely, regardless of mental status at the time of admission). Monitor for signs of increased ICP.
- Frequently present with signs and symptoms of an acute abdomen that responds to rehydration.
- Consider sepsis evaluation if febrile.

Useful equations

- Estimated Osmolality = 2(Na+) +(glucose/18) + (BUN/2.8)
- Corrected Sodium (mEq/L) for hyperglycemia = Na+ + [0.016* (measured glucose – 100)]
- * Some report 0.024 as the correction factor.

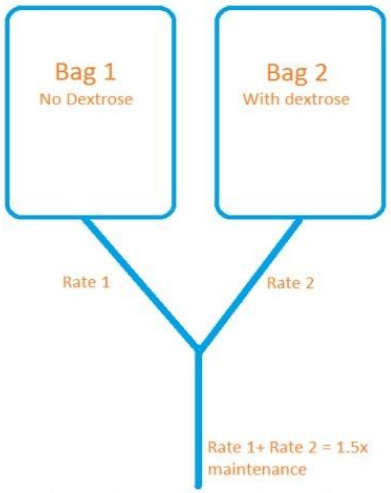
Two bag system for IV rehydration in DKA - MMC-POR & MMC-BIDSAN

Demographics		
Patient Weight		kg
Maintenance IVF rate	0	mL/hr
1.5 x Maintenance	0	mL/hr

Rates for IV repletion		Bag 1 - mL/hr		Bag 2 - mL/hr	
If blood glucose (mg/dL)	>350	0	(100%)	0	(0%)
If blood glucose (mg/dL)	301-350	0	(75%)	0	(25%)
If blood glucose (mg/dL)	251-300	0	(50%)	0	(50%)
If blood glucose (mg/dL)	201-250	0	(25%)	0	(75%)
If blood glucose (mg/dL)	60-200	0	(0%)	0	(100%)
If blood glucose (mg/dL)	<60	0	(0%)	0	(100%)
Call resident immediately and hold insulin infusion					

Components of the fluid

	Bag 1	Bag 2	
Dextrose	None	D10%	*Note components are different
Base	Normosol "Multiple Electrolytes"	Normosol "Multiple Electrolytes"	
Additive 1	+15 mmol/L Potassium Phosphate	+15 mmol/L Sodium Phosphate	*Note components are different
Additive 2	+10 mEq/L Potassium Chloride	+40 mEq/L Potassium Chloride	*Note quantity is different



Two bag system for IV rehydration in DKA: Referring hospital or Transport

1.5 x Maintenance		mL/hr

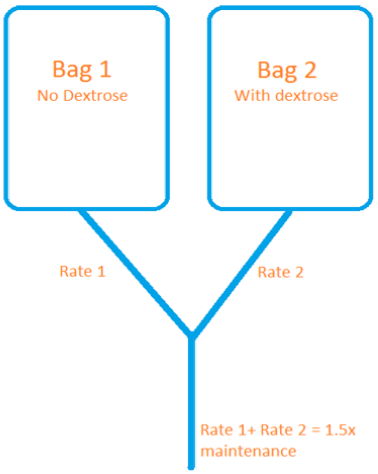
Rates for IV repletion		Bag 1 - mL/hr	Bag 2 - mL/hr
If blood glucose (mg/dL)	>350	100%	0%
If blood glucose (mg/dL)	301-350	50%	50%
If blood glucose (mg/dL)	251-300	25%	75%
If blood glucose (mg/dL)	201-250	0%	100%
Decrease insulin to 0.08 units/kg/hr			
If blood glucose (mg/dL)	60-200	0%	100%
Decrease insulin to 0.05 units/kg/hr			
If blood glucose (mg/dL)	<60	0%	100%
Call resident immediately and hold insulin infusion			

Options for fluids

Bag 1 Lactate Ringer's + 40mEq KCl
Bag 2 Dextrose 5% + Lactate Ringer's + 40mEq KCl

OR

Bag 1 0.9% Saline + 40mEq KCl
Bag 2 Dextrose 5% + 0.9% Saline + 40mEq KCl



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